R&D policies to transform and decarbonise the energy system and markets: Singapore

IEA EGRD Workshop on
"Future Energy Market Designs: Research and Innovation Needs "
October 2018, Berlin

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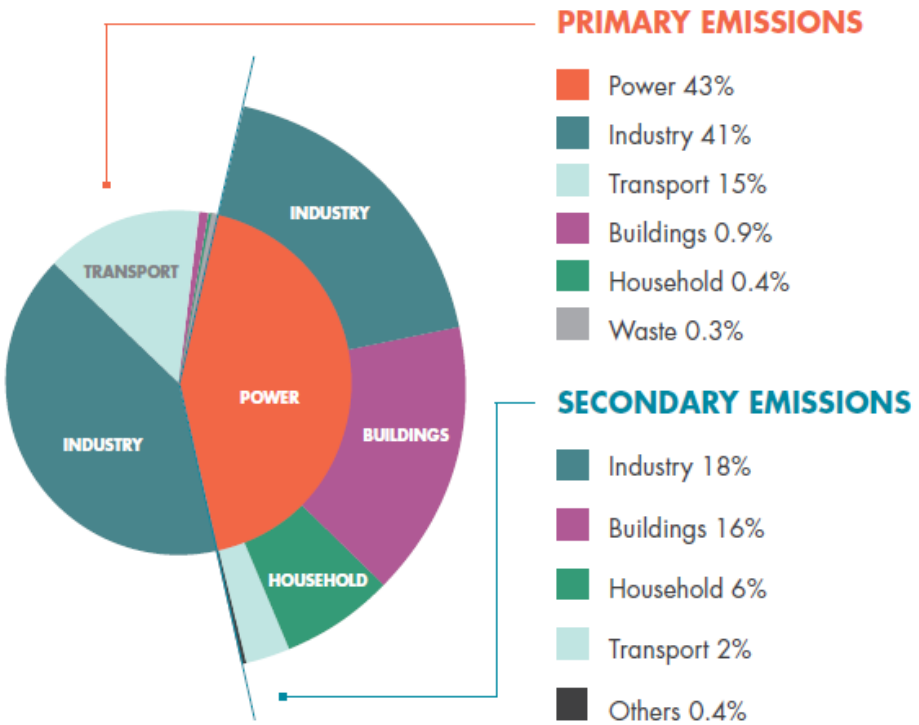
Singapore's CO_2 emissions profile (in 2012)



PRIMARY EMISSIONS

- Power 43%
- Industry 41%
- Transport 15%
- Buildings 0.9%
- Household 0.4%
- Waste 0.3%

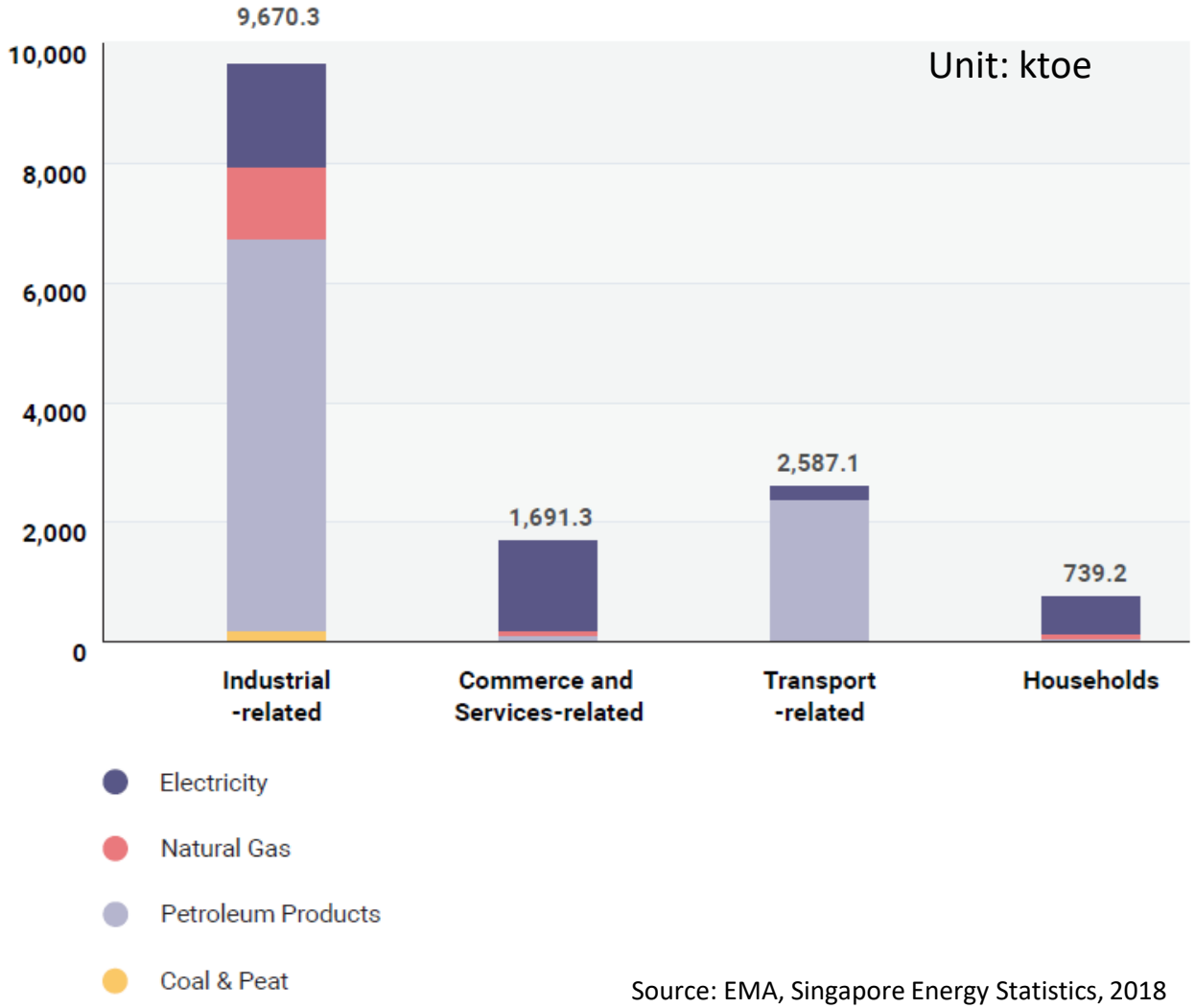
SECONDARY EMISSIONS

- Industry 18%
- Buildings 16%
- Household 6%
- Transport 2%
- Others 0.4%

Primary emissions refer to emissions from direct combustion of fuels, whereas secondary emissions result from electricity consumption

Source: NCCS, Climate Action Plan, 2016

Singapore's Final Energy Consumption Profile (2016)



Source: EMA, Singapore Energy Statistics, 2018

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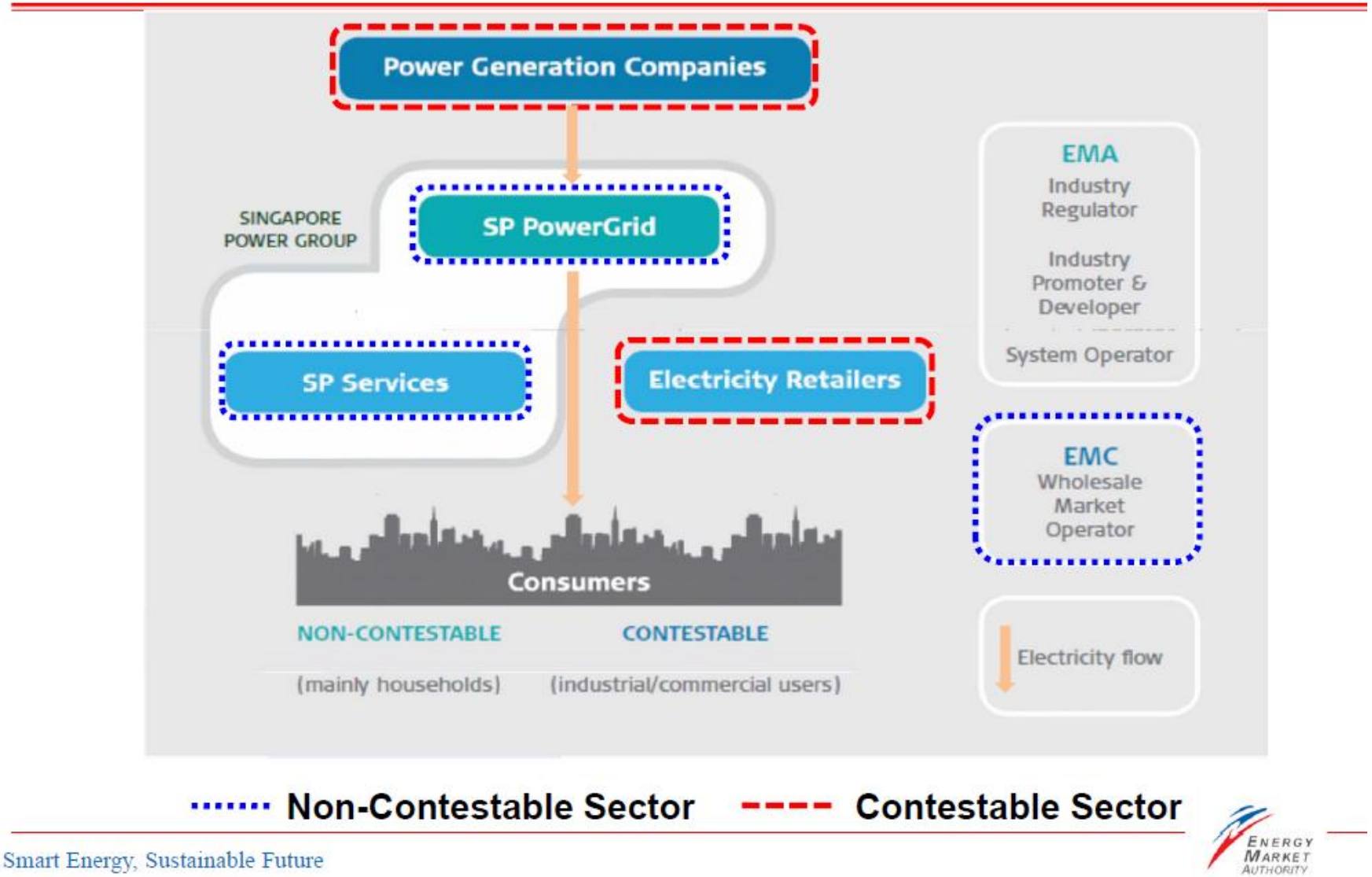
Singapore's electricity market framework



Smart Energy, Sustainable Future

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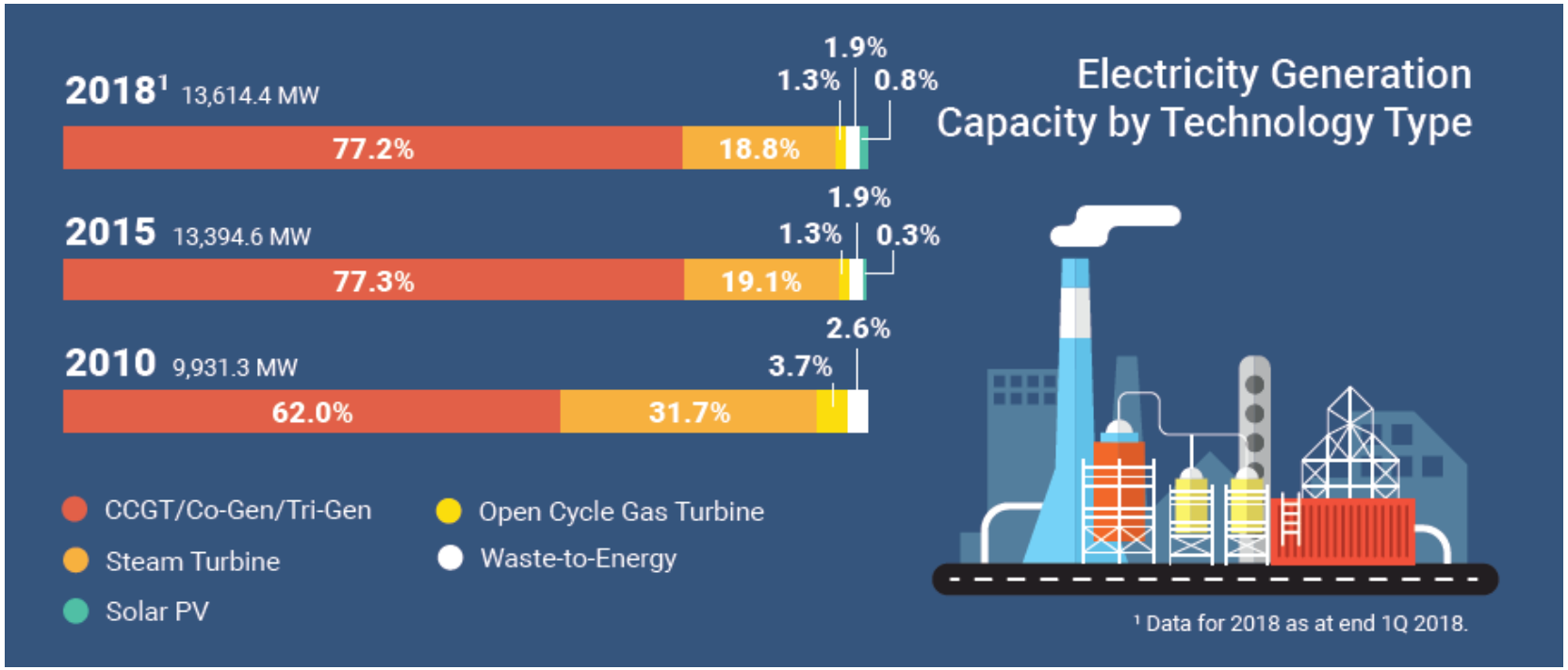
Source: Energy Market Authority

Singapore: Electricity Generation Profile

- Total generation capacity of 13.6 GW, with peak demand of around 7 GW
- Natural gas power plants also account for more than 77% of installed capacity
- In 2018, 95% of electricity generated from natural gas power plants - mainly combined cycle gas turbine plants (CCGTs)



Source: EMA, Singapore Energy Statistics, 2018

- Singapore's Grid Emission Factor (GEF) - ***0.4192 kg CO2/kWh*** in 2017
- Cogeneration plants (both centralized and "embedded autogenerators" contributing a larger share of electricity generation
- Waste to energy and renewable energy (mainly biomass and solar) contributed around 2.1% of generated electricity
- Solar PV deployment was around 115 MW_{ac} (150 MW_{p}) in Q1, 2018

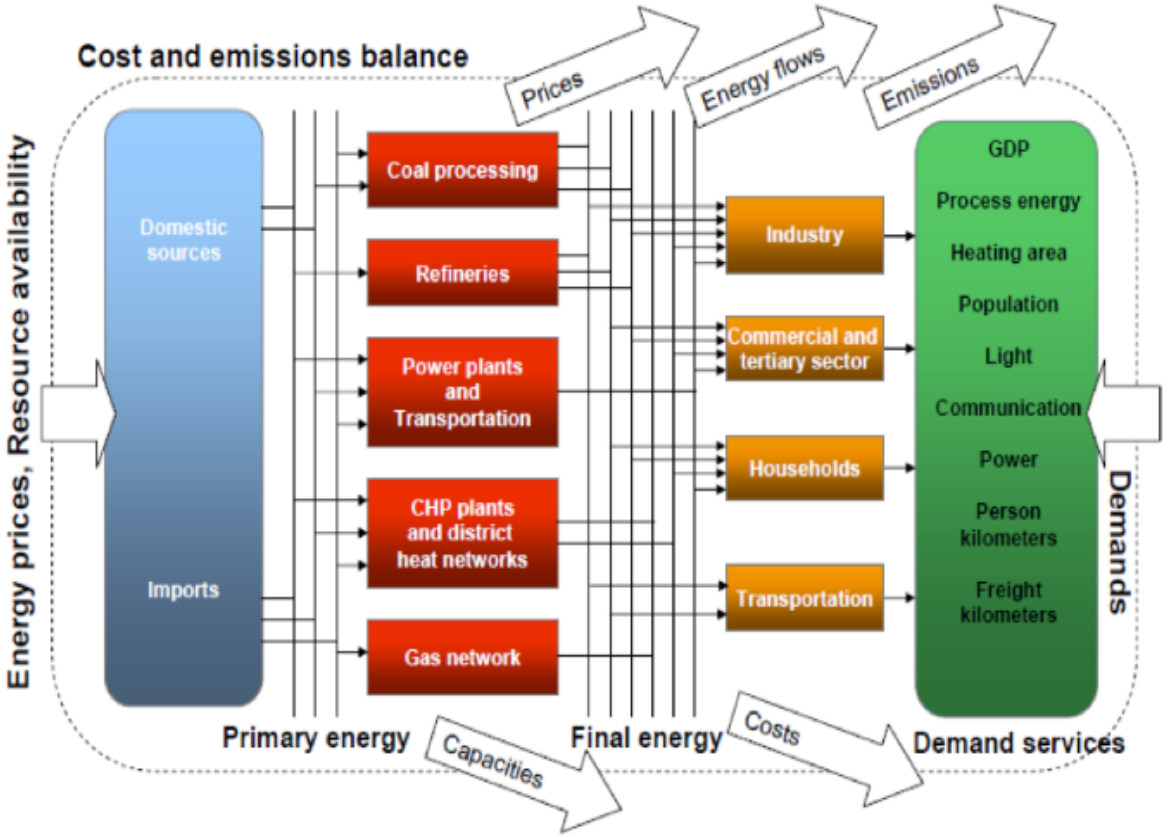
General R&D and Innovation Policies in Singapore

- Objective: Investments in research, innovation and enterprise will lay the foundation of Singapore's Future Economy, creating good jobs, sharpening our economic competitiveness, overcoming our constraints and transforming Singapore into a Smart Nation.
- Led by a Research, Innovation and Enterprise (RIE) Council chaired by PM of Singapore
- Government R&D investment has increased from $2 billion in 1991-96 (1st National Technology Plan) to **$19 billion** in the RIE Plan for 2016-20.
- Four "shifts" under RIE 2020 plans:
  - Closer Integration of Strategies. Encourage multi-disciplinary, multi-stakeholder collaboration
  - Stronger Dynamic for Renewal – higher allocation to competitive funding compared to institutional and other funding, and more "White Space" funding
  - Sharper Focus on Value Creation - additional budget allocation towards public-private research collaborations and increased efforts in helping companies expand their absorptive capacities for new technologies
  - Better Optimised RIE Manpower – Build a strong Singaporean research manpower core and also strengthening with international talent.
- Main areas supported domains are in Advanced Manufacturing and Engineering (AME), Health and Biomedical Sciences (HBMS), Services and Digital Economy (SDE) and **Urban Solutions and Sustainability (USS)**

Energy R&D landscape

- Energy R&D Funding is largely through RIE 2020 Urban Solutions and Sustainability (USS) domain directed by the National Research Foundation
- In 2017, the ***National Energy Transformation Office (NETO)*** was formed within the Energy Market Authority (EMA) to synergise energy R&D efforts across different government agencies.
- NETO will adopt a whole of government perspective in planning and coordinating energy RD&D funding and initiatives, and enabling policies for the adoption of transformational energy solutions, including recommending/making *"Build or Buy"* decisions
- NETO and EMA are working closely with many other agencies including the *National Climate Change Secretariat (in PMO Strategy Group)*, Building & Construction Authority, National Environment Agency, Economic Development Board, Info-Comm and Media Development Authority, as well as with research performers in academic institutions and the private sector.
- In addition to the continuing focus on reducing costs and increasing reliability and security of the energy/electricity system, energy R&D will also contribute to long term emissions reduction strategy

Energy system modelling and Technology roadmaps



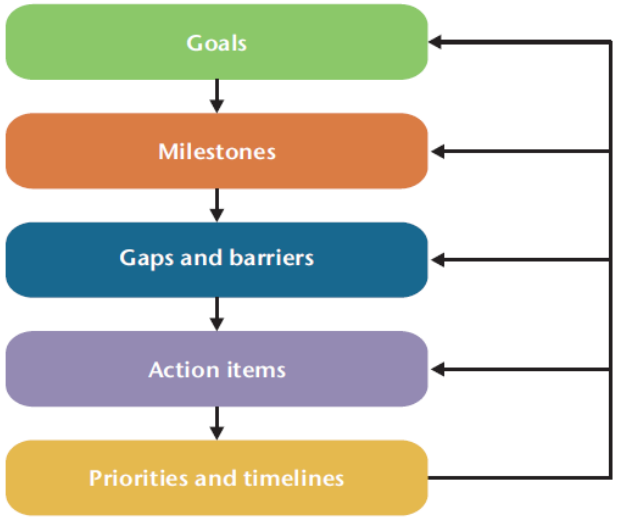
MARKAL Singapore energy system model framework
[Source: Energy Studies Institute, NUS]

All these technology roadmaps and studies are either being updated or complementary studies have been commissioned to provide additional insights and analysis. Roadmaps particularly important for reduction of industry sector emissions are the **Industry Energy Efficiency Roadmap**, and the **Carbon Capture, Utilisation and Storage Roadmap**

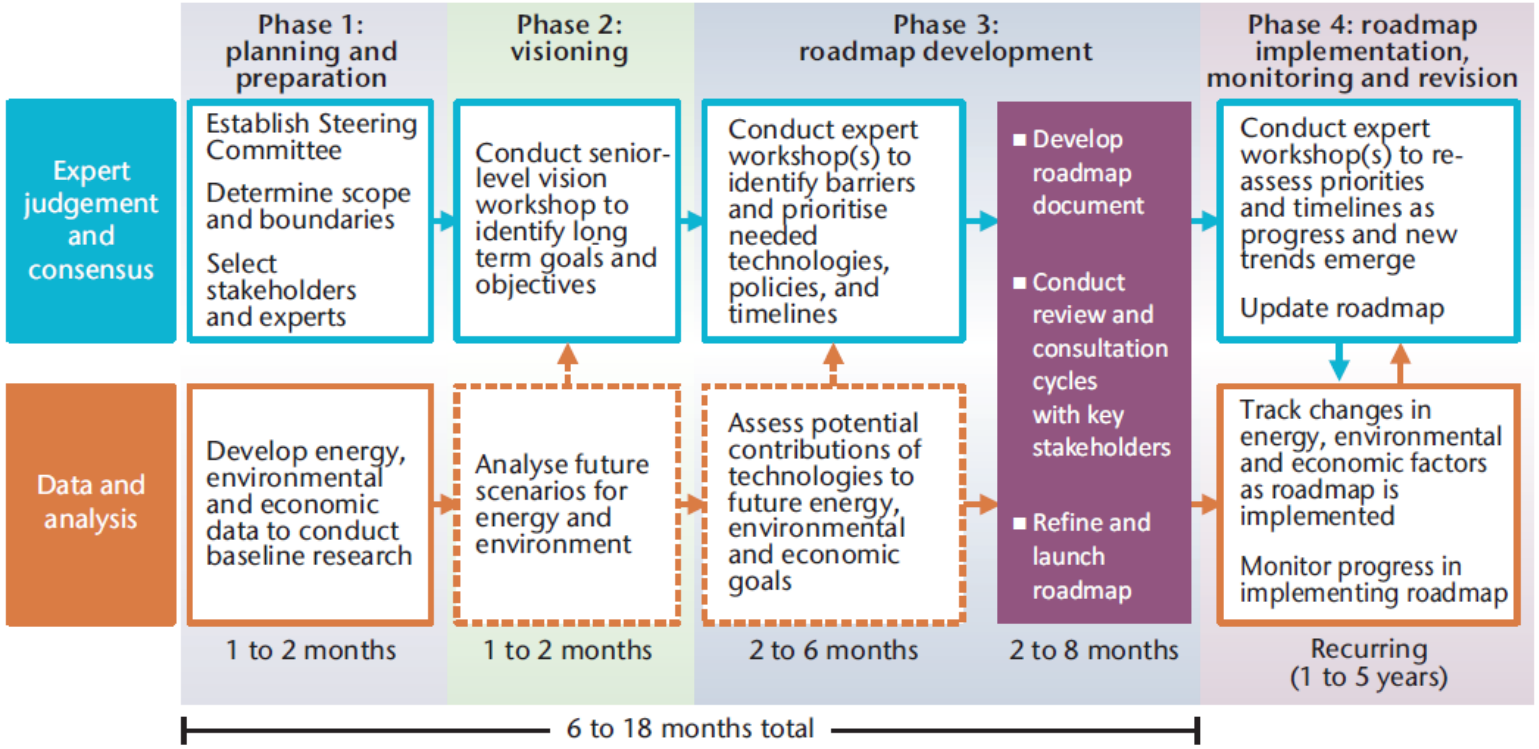
Development of Technology Roadmaps (TRMs)

- Definition

  A Technology Roadmap (TRM) serves as a coherent basis for specific technology development and transfer activities, providing a common (preferably quantifiable) objective, time-specific milestones and a consistent set of concrete actions; developed iointlv with relevant stakeholders. who commit to their roles in the TRM implementation.[1]



Key Elements



Outline of Roadmap Process

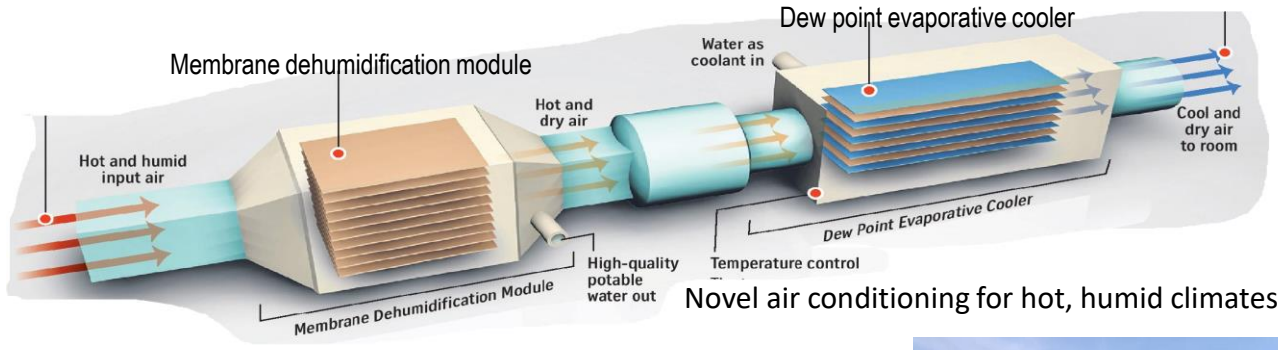
Source: "Energy Technology Roadmaps – a guide to development and implementation", International Energy Agency (IEA), 2014.

1. *From: UNFCCC Technology Executive Committee (TEC) Background paper on Technology Roadmaps (TEC/2013/5/5)*

RD&D efforts in Urban Solutions and Sustainability

R&D Funding

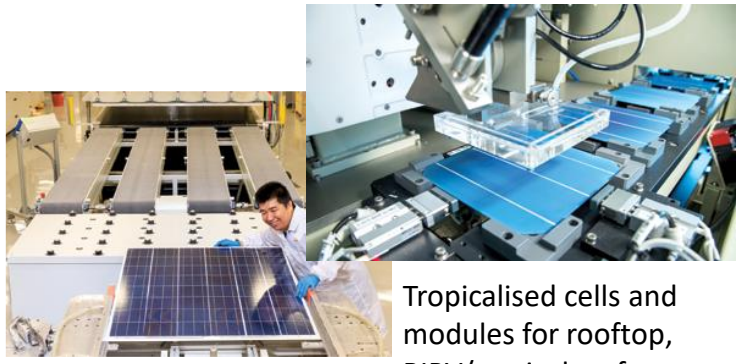
S$470M	S$365M	S$300M	S$900M
2006: Clean Water Strategic Research Programme	**2007:** Clean Energy Strategic Research Programme	**2011:** Energy National Innovation Challenge	**2016:** Urban Solutions and Sustainability



Novel air conditioning for hot, humid climates

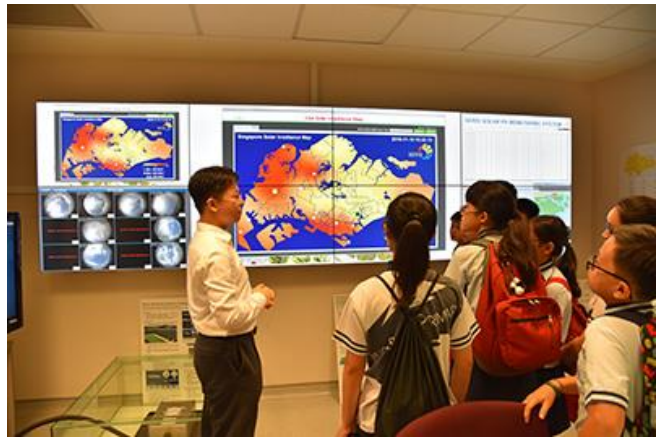
Wastewater reclaimation/treatment - Newater

Examples of New Technologies



Tropicalised cells and modules for rooftop, BIPV/vertical surfaces

Floating solar PV



Solar output forecasting – improve grid integration

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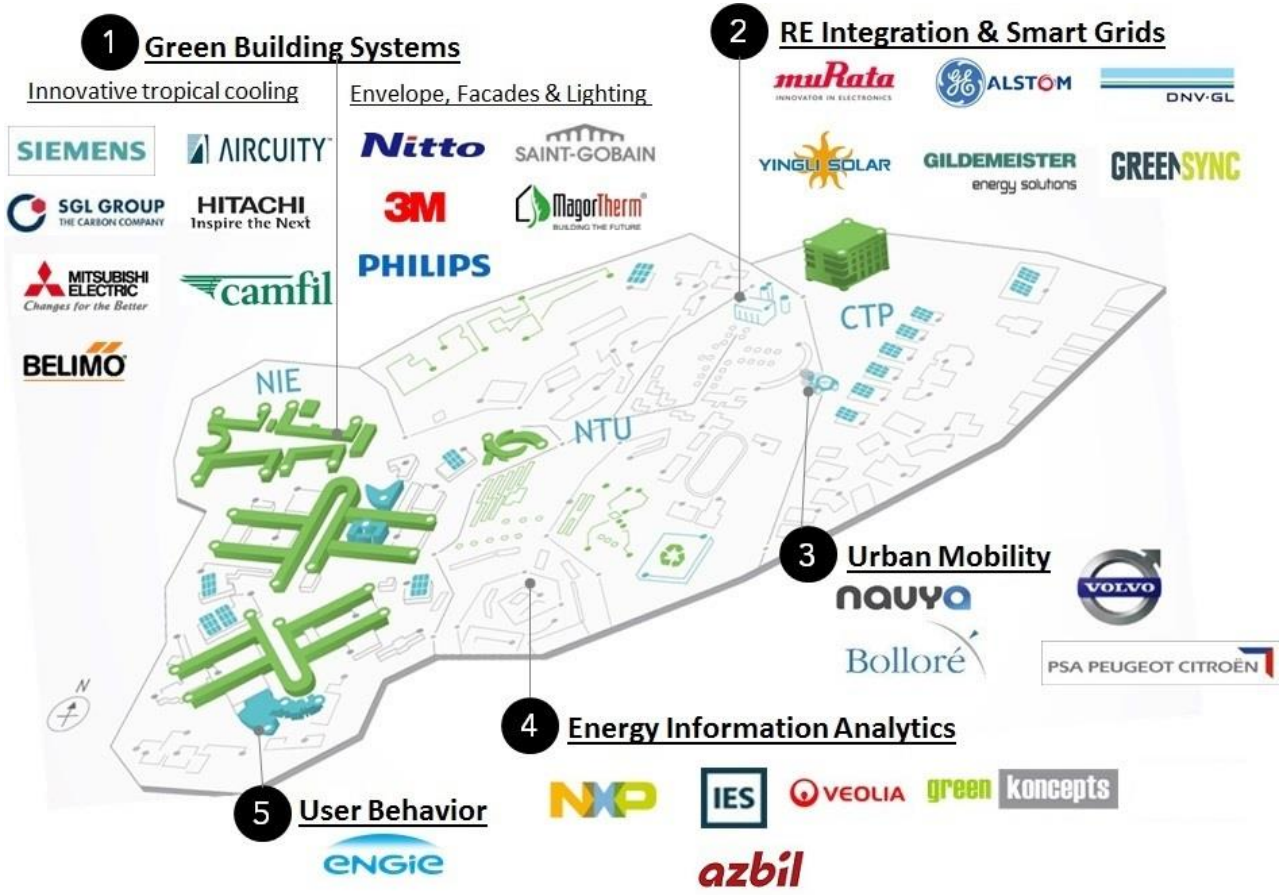
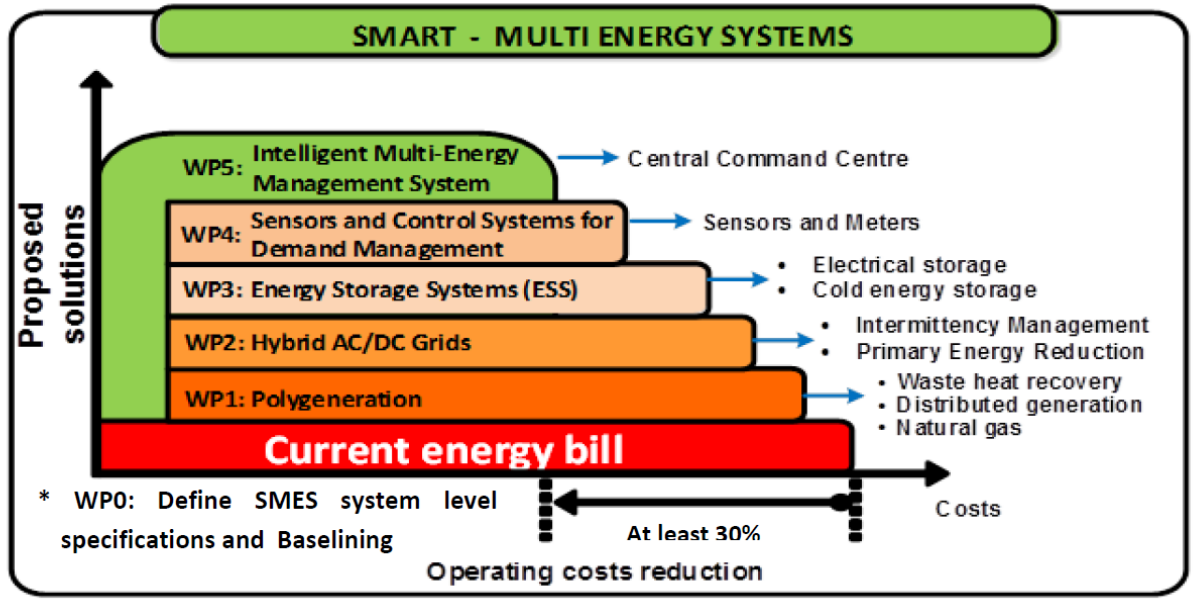
Sources of illustrations/photographs: Straits Times, SERIS (Solar Energy Research Institute of Singapore), PUB Singapore

Examples of system-level high TRL research and demonstration: Eco Campus (Living Lab) and Smart Multi Energy System project - NTU (Nanyang Technological University)





Source: Nanyang Technological University

These efforts are being followed up currently with a major RD&D initiative on **Energy Grid 2.0** – transforming energy at district scale

Challenges and Potential Disruptions to Electricity market ….. Leading to R&D needs

- Maintain world class electricity system reliability and affordability
- Improve resiliency (through both centralised and decentralised/distributed approach)
- Improve efficiency and reduce carbon emissions
  - Support higher level of Variable renewable energy (solar PV) – perhaps up to 10 GWp*
    - From rooftops to vertical surfaces, canopies and temporary vacant land
    - Floating solar (reservoirs and coastal waters)
    - Improve efficiency and reduce space utilisation
    - Manage both variability and uncertainty associated with solar PV
  - Support increased electrification of demand (data centres, heat pumps, EV/AVs)
  - Support Renewable/clean electricity or fuel imports, and or CCSU (Carbon Capture, Storage and Utilisation)
  - Support Decentralised generation, embedded generation/cogeneration/trigeneration, district energy systems

* Based on scenario in Solar PV roadmap for Singapore, SERIS, 2014

Examples of Policy Innovations in electricity market

- Further liberalisation - Open Electricity Market (OEM) – all customers can choose their retailers
- Making it easier to deploy solar and distributed energy resources
- Carbon tax applied to power plants and other large emitters
- Ongoing efforts on EVs/charging infrastructure and potential V2G
- Intermittency Pricing Mechanism for spinning reserves – “causer-pay” principle
- Increase potential of Demand management/response
- Energy storage – white paper being developed

Examples of R&D needs and efforts for electricity system

- Grid modelling at different spatial levels and time scales to maintain grid reliability, stability, quality with increased VRE, demand electrification (esp. EVs), potential imports
- Smart grid technologies to enhance reliability, resiliency, efficiency and optimise performance
- Energy storage technologies
- Improve efficiency and reduce emissions – CCGTs, Integrated systems, CCSU

Key Messages

- Singapore is investing heavily in energy RD&D to meet the challenges and potential disruptions to its energy and electricity system with decarbonisation as a relatively new and important driver.
- For electricity system/market, key technology research areas include smart technologies to maintain high reliability and quality of service, solar PV and its integration into the grid – including technologies to enhance grid flexibility such as storage, solar forecasting, flexible generation
- Research and implementation of Policy and regulatory innovations, and further tweaking of competitive market framework are also needed

Thank you for your attention